EXPERIMENTING A PERMANENT GEOELECTRICAL MONITORING SYSTEM FOR STABILITY ASSESSMENT OF LEVEES

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Background and Aim of the Study

Due to the floods that have occurred in different countries all over Europe, hydrogeological risk related to levee breach has become a hot problem in last few years (Fig. 1), but objective methods of monitoring the inner situation of embankments are not widely available. In last decades, geophysical techniques have been used frequently to assess levee's health [1, 2]. Geoelectrical methods have been specifically employed to underline non homogenous seepage [3, 4, 5], but only in few cases a long term monitoring system has been implemented [6, 7].

The aim of this work is to establish a way to evaluate the stability of earthen levees in an indirect, cost-effective and reliable way. This aim is followed through a permanent geoelectrical monitoring system to control soil saturation and seepage through the embankment.

Fig. 1 Serchio flood (2009)

Materials & Methods

- **Test site**

Fig. 2 Consorzio Di Bonifica Terre dei Gonzaga in Destra Po

Fig. 3 San Giacomo delle Segnate (Mantua, Italy)

Fig. 4 Site 1 Via Marconi

Fig. 5 Site 2 Via Dugale

- **Preliminary time lapse tests** (with IRIS Syscal Pro)

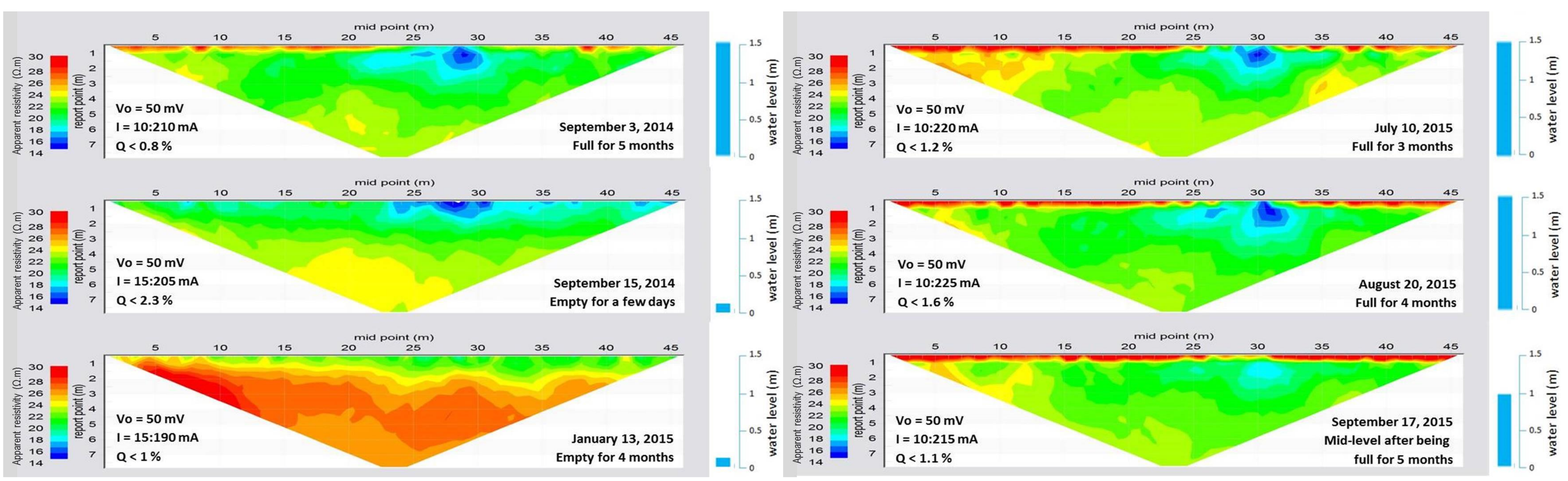

Fig. 6 Pseudosections of preliminary time lapse tests (Sep. 2014 - Sep. 2015) in Site 2 (Fig. 5) with evidence of a seepage zone which changes during the irrigation seasons until it collapses (Sep.2015)

- **Prototype design and installation**

- Buried parts resistant to external agents (Fig. 7)
- Programmability of parameters
- Sending data by internet
- Low energy demanding device (Fig. 8)
- Shallow investigation depth (10 m)
- Low-cost device
- Plate electrodes (Fig. 9)
- Availability of a meteorological station at the site

Fig. 7 Plastic case

Fig. 8 Solar panel

Fig. 9 Plate electrode

- **Comparison with a commercial device** (IRIS Syscal Pro)

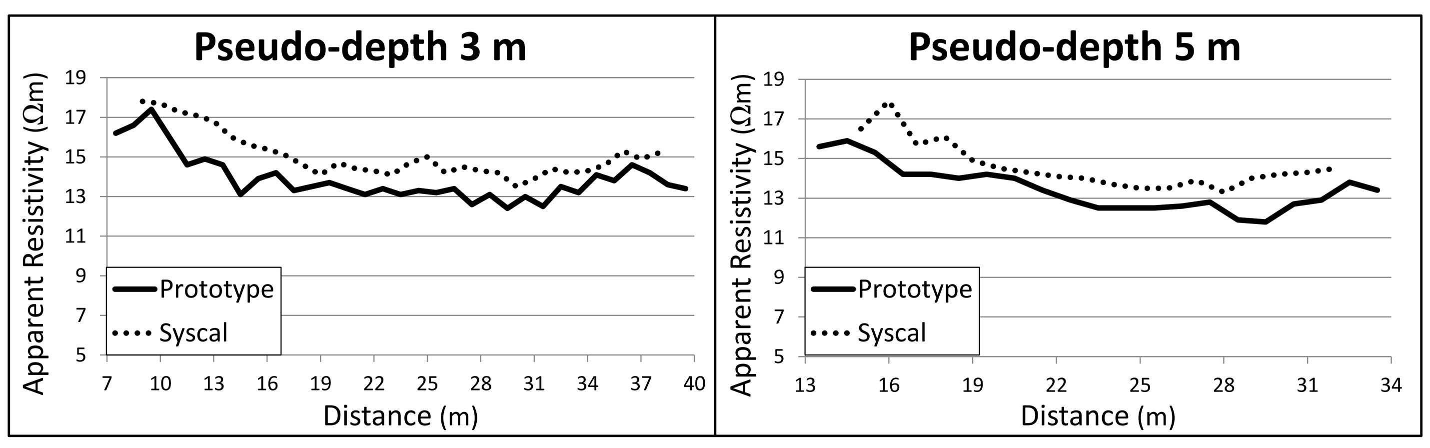

Fig. 10 Comparison of apparent resistivities at different pseudo-depths. The difference is 10% maximum and is mainly due to different depths of electrodes

Results and Discussion

- **Analysis of the monitoring data**

Data obtained for more than 2 years have been analysed in order to underline relations between resistivity values and external variables such as water level in the irrigation canal and rainfalls. Daily resistivity pseudo-sections have been inverted using Res2dInv software and external variables have been collected by a meteo station at the site. Seepage conditions in the levee body are different in depth and during the year:

- Top and bottom parts of the structure experience infiltration due to rainfall events (a lateral ditch collects rain water)
- Medium depths of the levee are characterised by horizontal seepage from the irrigation canal
- During the emptying procedure, sharp variations in resistivity values are recorded (Fig. 11)
- During the filling procedure, smooth resistivity variations are observed

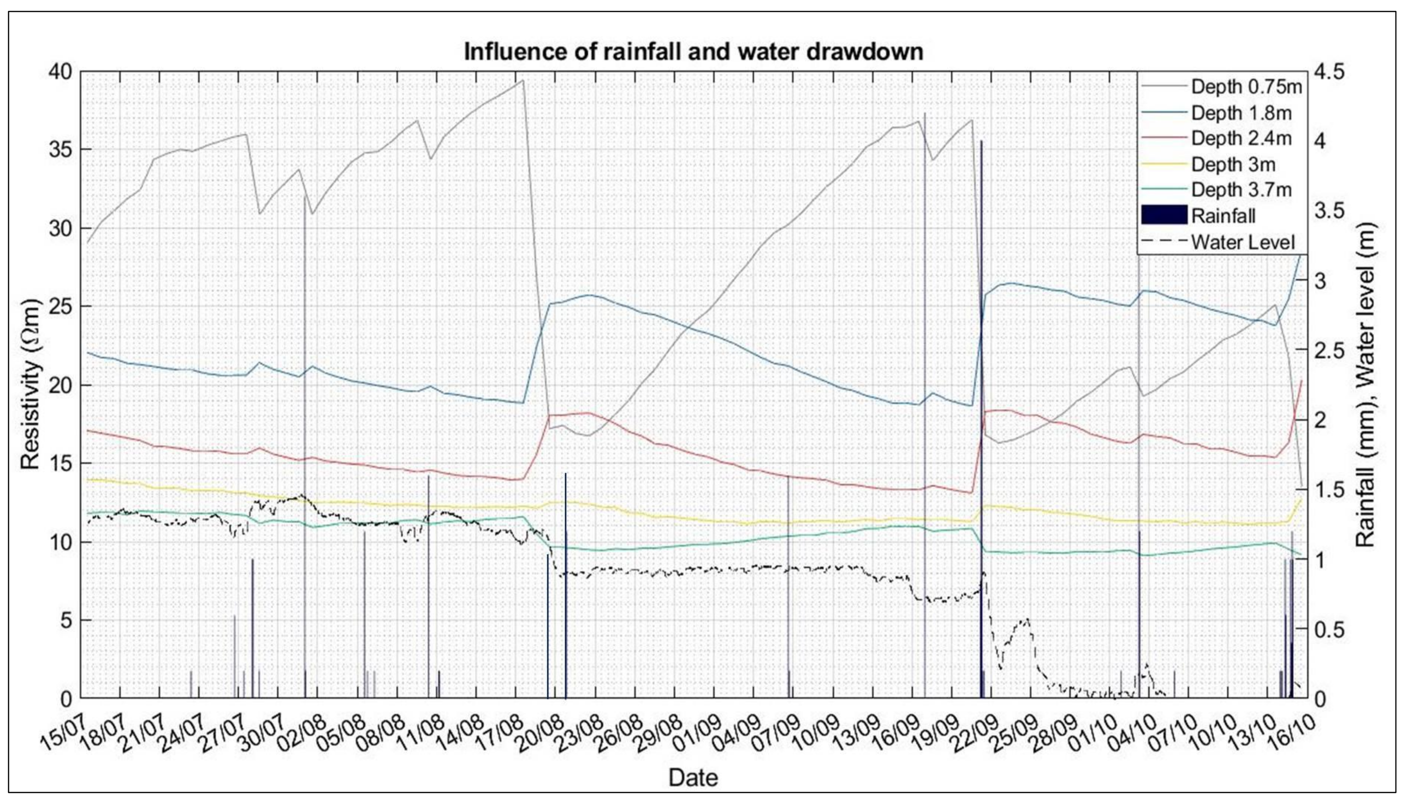

Fig. 11 Influence of rainfall and water drawdown on inverted resistivities at different depths (15/07/16 – 15/10/16)

- **Water content vs Resistivity function**

- Manual drilling
- 10 samples down to the base of the embankment
- Analysis of samples in the lab
- Resistivity measurements by the installed prototype
- Fitting of water content vs. inverted resistivity data using a power function (Fig. 12)

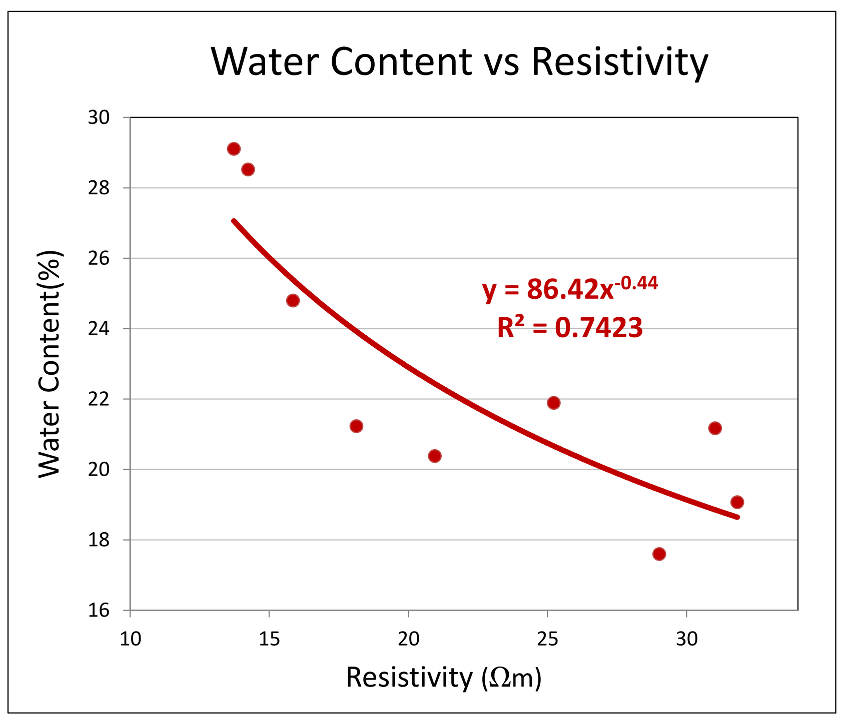

Fig. 12 Water Content vs Resistivity function

Conclusions

- Good response of ERT methodology to levee stability problems
- Energy efficiency, low cost and reliability of the prototype
- Rainfall influences top and bottom parts of the levee
- Water level influences resistivity values at medium depths: during emptying period, variations seem to be very rapid, while at the beginning of the irrigation period, reactions to water level increase are very smooth
- Empirical site dependent function for water content vs resistivity was calibrated using core sample data

Acknowledgments

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References: **[1]** Kim J.-H. et al. J. of Environ. and Eng. Geophys. 2007, 12(2), 221-235. **[2]** Cardarelli et al. J. of Appl. Geophys. 2014, 106, 87-95. **[3]** Takakura S. et al. In Proc. 11th SEGJ International Symposium. 2013, 248-251. **[4]** Perri M. T. et al. J. of Appl. Geophys. 2014, 110, 5-22. **[5]** Loperte A. et al. Eng. Geol. 2016, 211, 162– 170. **[6]** Hilbich C. et al. Permafr. Periglac. Process. 2011, 22, 306-319. **[7]** Supper R. et al. In: Proc. GELMON 2011.